CHAPTER 11
BLAST AND FRAGMENT PROTECTION

11-1. Introduction.

a. This chapter describes the blast and fragment protection requirements for unintentional and intentional detonations. These requirements should be addressed by the project team when planning and conducting an OE response action. A checklist of planning considerations has been provided as Attachment 11-1.

b. The minimum separation distance calculated to perform work on an OE site may include the minimum separation distance for unintentional OE detonations, intentional OE detonations, or both depending on the SOW for the site. Preliminary site work performed at an OE-contaminated site, such as surveying, laying out search lanes, and non-intrusive geophysical investigations, do not require the establishment of a minimum separation distance. The minimum separation distance requirements for intentional and unintentional detonations are discussed in the following paragraphs.

11-2. Data Quality Objectives. When evaluating the blast and fragment protection components of an OE project, the project team should consider data quality objectives in the following areas:

a. Calculation of minimum separation distances in accordance with DOD 6055.9-STD, Ammunition and Explosives Safety Standards;

b. Proper design and approval of engineering controls; and

c. Procedures for reviewing government and contractor planning documentation.

11-3. Explosives Safety Considerations.

a. General. When developing the SOW for an OE project, the project team will need to evaluate several resources to find information relating to the current characteristics of the site, the type of OE project being proposed, the historical use of the site, and the nature of the OE items that were used at the site. These resources may include:

(1) INPR;

(2) ASR;

(3) Historical records relating to the operation of the installation;

(4) Previous site investigation reports; and

(5) Other historical or investigative reports which may give an indication of the current state of the site.

b. Reviewing this background information is essential to determine the level of involvement of the structural engineering branch in the proposed project. Specific site characteristics that should be examined when reviewing these reports include:

(1) Site layout;

(2) Land use of the project site and the surrounding area;

(3) Physical characteristics of the project site (e.g., topography, vegetation); and

(4) Man-made structures on the site (e.g., buildings, roads).

c. OE Response Action. The type of OE response action proposed for a site will influence the type and amount of blast and fragment protection requirements for a project. The project team will need to consider the type of OE response action being proposed for the site, such as:

(1) UXO Support;

(2) EE/CA; or

(3) Removal Action.

d. Probable Ordnance Characteristics. The project team will need to consider the type of OE items that could potentially be found at the project site. This information may be obtained from any archival information available on the project site or from any other reports that have previously been generated. Some of the elements to be considered in this category include:

(1) Conventional versus chemical OE items;

(2) Live versus inert OE items;

(3) The type and amount of OE anticipated;

(4) The potential age, condition, and burial depth of OE; and

(5) The potential fuzing of the OE items.

e. Most Probable Munition. For all OE sites, a Most Probable Munition (MPM) must be determined. The MPM is that OE item that has the greatest hazard distance based on calculations of the explosion effects of the OE items anticipated to be found at a site. Typically, the MPM is the OE item with the greatest fragmentation or overpressure distance based on the type of OE items that were historically used at the site. The project team should select the correct MPM for the site based on the available historical site information such as that listed in paragraph 11-2.

f. Explosive Soils. For explosive soils, the MPM concept does not apply. Instead, the concept of maximum credible event (MCE) applies. For soil, the MCE is the concentration of explosives times the weight of the mix. For example, 1000 pounds of soils containing 15 percent Trinitrotoluene (TNT) has an MCE of 150 pounds. When the concentration varies within the area, weighted averages or any other valid mathematical technique can be used, as long as the technique is explained and technically supported in the submission. Overpressure and soil ejecta radius must be considered when determining the Quantity Distance (Q-D) for explosive soils. For additional information on explosive soils, contact the OE MCX.

11-4. Explosion Effects.

a. A major component of the structural engineering branch's involvement during an OE project is the calculation of minimum separation distances for unintentional and intentional detonations of OE items. A review of the explosion effect calculations that should be used by the project team in the determination of minimum separation distances is provided in this paragraph. This paragraph also provides the source documentation for these minimum separation distance calculations.

b. There are six factors of an OE detonation that should be considered by the project team when either siting an area for intentional OE detonations (such as when setting up an Open Burn/Open Detonation area) or when the possibility exists of an unintentional detonation during the course of an OE site investigation. These six factors include:

(1) Fragmentation;

(2) Overpressure;

(3) Thermal flux;

(4) Ground shock;

(5) Noise; and

(6) Ejected soil.

c. Controlling Factors. To determine the appropriate minimum separation distance, the project team should use the explosion effect calculation that yields the greatest minimum separation distance, unless an engineering control will be used to limit the explosion effect. Typically, either fragmentation or overpressure is the controlling factor in determining the necessary minimum separation distance. However, thermal flux and soil ejecta may become controlling factors if a buried detonation is planned, as discussed in paragraph 11-4d.

(1) Fragmentation. The method to be used in determining the separation distance due to fragmentation depends upon whether the circumstance is an unintentional or intentional detonation. For both intentional and unintentional detonations, the standards listed in Chapter 5, paragraph C.5.5.4, DOD 6055.9-STD should be used. In accordance with this paragraph, the maximum fragment throw range for a specific item, with an appropriate safety factor, may be used to replace the default distances listed in paragraph C5.5.4. USAESCH has developed approved methodologies to determine OE item-specific fragment throw ranges. These methodologies are detailed in HNC-ED-CS-S-98-1, “Methods for Predicting Primary Fragmentation Characteristics of Cased Explosives”, and HNC-ED-CS-98-2, “Method for Calculating Range to No More Than One Hazardous Fragment per 600 Square Feet”.

(2) Overpressure. The method to be used by the project team in determining the minimum separation distance for overpressure is the same for both unintentional and intentional detonations. In both circumstances, the equation D=KW1/3 is used. However, the safety factor ‘K’ differs depending on whether the circumstance is an unintentional or intentional detonation. For unintentional detonations a K value of 50 should be used, while for intentional detonations a K value of 328 should be applied.

d. Secondary Factors. The following secondary factors are considered in calculating minimum separation distances. These factors are typically not controlling factors in minimum separation distance determinations.

(1) Thermal Flux. Thermal flux will rarely be a controlling factor in minimum separation distance determinations. However, in some instances, the thermal flux generated from the exothermic reactions that result from the detonation of certain OE items may generate a minimum separation distance greater than either the fragmentation or overpressure distance. The project team should use the same method for determining the minimum separation distance based on thermal considerations for both unintentional and intentional detonations. The project team should use the standards listed in Technical Manual (TM) 5-1300, Structures to Resist the Effects of Unintentional Explosions, to determine the minimum separation distance due to thermal flux. If the minimum separation distance due to thermal flux listed in TM 5-1300 cannot be met, then shields complying with MIL-STD-398, Shields, Operational for Ammunition Operations, Criteria for Design of and Tests for Acceptance, should be used to provide an acceptable level of thermal protection.

(2) Ejected Soil. The project team should calculate the distance that soil may be ejected as a result of an intentional detonation. In addition to the hazards posed by ejected soil during a subsurface OE detonation, the burial depth calculation may also assist in determining the amount of earth cover necessary to defeat the fragmentation generated during an OE detonation. A

computer model has been created to assist in determining the amount of earth cover necessary to mitigate the fragmentation hazard from an OE detonation. The project team should reference HNC-ED-CS-S-97-7-Revision 1, Buried Explosion Module: A Method for Determining the Effects of Detonation of a Buried Munition, for additional details on the use of this computer model.

(3) Ground Shock. The project team should use the same method for determining the minimum separation distance based on ground shock for both unintentional and intentional detonations. In those areas where vibration damage may occur due to an OE detonation, the project team should consult the requirements listed in TM 5-1300. In addition, state and local regulations may exist that are more stringent than the federal regulations. As a result, local regulators should be contacted during the planning process to determine the level of ground shock allowed according to any local codes.

(4) Noise. The project team should use the same method for determining the minimum separation distance based on noise for both unintentional and intentional detonations. The project team should use the criteria presented in paragraph 5-7k(2)(b), Department of the Arm (DA Pam) 385-64, Ammunition and Explosives Safety Standards. In addition, state and local regulators should be contacted during the planning process to determine if there are more stringent local regulations in regards to noise generated as a result of an OE detonation.

11-5. Minimum Separation Distances.

a. The project team should ensure that, if practical, the Department of Defense Explosives Safety Board (DDESB) minimum separation distances, as promulgated in Chapter 5, paragraph C5.5.4, DOD 6055.9-STD, have been used.

b. In addition to these fragmentation guidelines, the project team should also ensure that the overpressure minimum separation distance has been correctly calculated using the equations outlined above using the K value of 50 for unintentional detonations and the K value of 328 for intentional detonations, in accordance with DDESB guidelines. If site constraints do not allow for the use of these minimum separation distances, then the project team will ensure that the minimum separation distances have been calculated in accordance with the methodologies detailed below in paragraphs 11-7 and 11-8.

11-6. Unintentional Versus Intentional Detonation Minimum Separation Criteria. When the project team or the UXO contractor determines the minimum separation distance to be used on an OE project, two sets of minimum separation distance criteria may need to be considered.

a. The first set of criteria has been established for unintentional detonations. An unintentional detonation is a detonation that is not planned in advance. Unintentional detonations are discussed in paragraph 11-7.

a. Minimum Separation Distance for Unintentional Detonations. The minimum separation distance for unintentional detonations is the safe separation distance for non-project personnel from intrusive operations. The minimum separation distance for unintentional detonations is calculated by taking the greatest value of:

(1) Overpressure at K value of 50.

(2) Fragmentation. When determining which fragment range to use, the project team should use the following guidelines. If the identification of the UXO expected at the site is unknown, the default distances listed in Chapter 5, paragraph C5.5.4, DOD 6055.9-STD will be used. If it is not practical to use these default distances and the identification of the UXO is expected at the site is known, then the maximum fragment throw range calculated in accordance with HNC-ED-CS-S-98-1 will be used. The item with the maximum fragment distance will become the MPM for the site. For unintentional detonations, the project team may request from the USAESCH OE Safety Branch, approval to use the range to no more than one hazardous fragment per 600 square feet (1/600 distance) calculated in accordance with HNC-ED-CS-S-98-2 in lieu of the maximum fragment throw range. The maximum fragment distances and the 1/600 distances will be calculated by the USAESCH Structural Branch and provided to the PM.

(3) 200 feet.

b. Team Separation Distance. The TSD is the distance the project teams must be separated during intrusive operations. The TSD is calculated by taking the greatest value of:

(1) Overpressure at a K value of 50, or

(2) 200 feet.

11-8. Intentional Detonations. The minimum separation distance for intentional detonations is the distance that both project personnel and the public must be from the intentional detonation. The minimum separation distance for intentional detonations is calculated by taking the greatest value of:

a. Overpressure at a K value of 328, or

b. The maximum fragmentation distance is determined in accordance with HNC-ED-CS-S-98-1 unless engineering controls are implemented. The item having the greatest distance will become the MPM for an OE area within a site, or

c. 200 feet.

b. The maximum fragmentation distance is determined in accordance with HNC-ED-CS-S-98-1 unless engineering controls are implemented. The item having the greatest distance will become the MPM for an OE area within a site, or

c. 200 feet.

11-9. Explosives Siting Plan.

a. General.

(1) The proposed minimum separation distances for unintentional detonations, intentional detonations, and siting of critical project components are discussed in the Explosives Siting Plan, a component of the project Work Plan. The Explosives Siting Plan will be reviewed by the project team to ensure that the appropriate minimum separation standards have been applied. The project team should review the Explosives Siting Plan to ensure that it properly describes the minimum separation distances and other safety criteria that will be employed during an OE operation. The following explosives operations will be described in the plan and sited on a site map with a minimum scale of 1 inch equals 400 feet:

(a) OE areas;

(b) Explosives storage magazines; and

(c) Planned or established demolition areas.

(2) The minimum separation distances calculated for the operation should be discussed in the text of the plan and Q-D arcs for the above-listed project elements drawn on the map.

b. Quantity-Distance. Explosives safety distance tables prescribe the necessary separations and specify the maximum quantities for various classes of explosives permitted in any one location. The Q-D tables provided in DOD 6055.9-STD reflect the acceptable minimum criteria for the storage and handling of various classes and amounts of explosives. These distances will be used for siting storage locations. The project should site Open Burn/Open Detonation areas in accordance with EP 1110-1-17, “Establishing a Temporary Open Burn and Open Detonation Site for Conventional Ordnance and Explosives Projects.”

c. OE Areas. The project team should confirm that the minimum separation distances during intrusive operations are determined in accordance with the criteria discussed in paragraphs 11-7 and 11-8.

d. Explosives Storage Magazines. The project team should ensure that the following items are discussed in the Explosives Siting Plan in regards to the Explosives Storage Magazine:

(1) Type of explosives storage magazine, (e.g. portable commercial, above ground, shed, earth-covered, etc.);

(2) NEW and hazard division to be stored in each magazine, (generally, recovered OE is considered to be Hazard Division 1.1);

(3) Q-D criteria used to site the magazine;

(4) Design criteria for any proposed engineering controls if the Q-D criteria cannot be met; and

(5) Designation of commercial explosives into a DOD Hazard Classification and Storage Compatibility Group by the U.S. Army Technical Center for Explosives Safety (USATCES) prior to being stored in a DOD facility. (See paragraph 16-3g, DA Pam 385-64 for procedure).

(6) Lightning Protection.

(a) FUDS. Lightning protection is not required if the following criteria are met:

- The magazine is constructed of metal that is 3/16-inch steel or larger (reference Appendix L of National Fire Protection Association 780);
- The magazine is grounded (see Figure 11-1); and
- The magazine is located at least 6.5 feet from the nearest fence.

(b) BRAC and Active Installations. Lightning protection for BRAC and active installations will meet the provisions in DOD 6055.9-STD.

e. Planned or Established Demolition Areas. The project team should confirm that the minimum separation distances are in accordance with the intentional detonation requirements (PSD) discussed in paragraph 11-8.

f. Footprint Areas. The project team will ensure that the following footprint areas are addressed in the Explosives Siting Plan. These areas, however, do not have to be shown on the map:

(1) Blow-in-Place Areas. Minimum separation distances for all personnel should be determined using the for intentional detonations requirements, as discussed in paragraph 11-8.

(2) Collection Points. Collection points, if used, should have the same minimum separation distance as that identified for unintentional detonations, as discussed in paragraph 11-7.

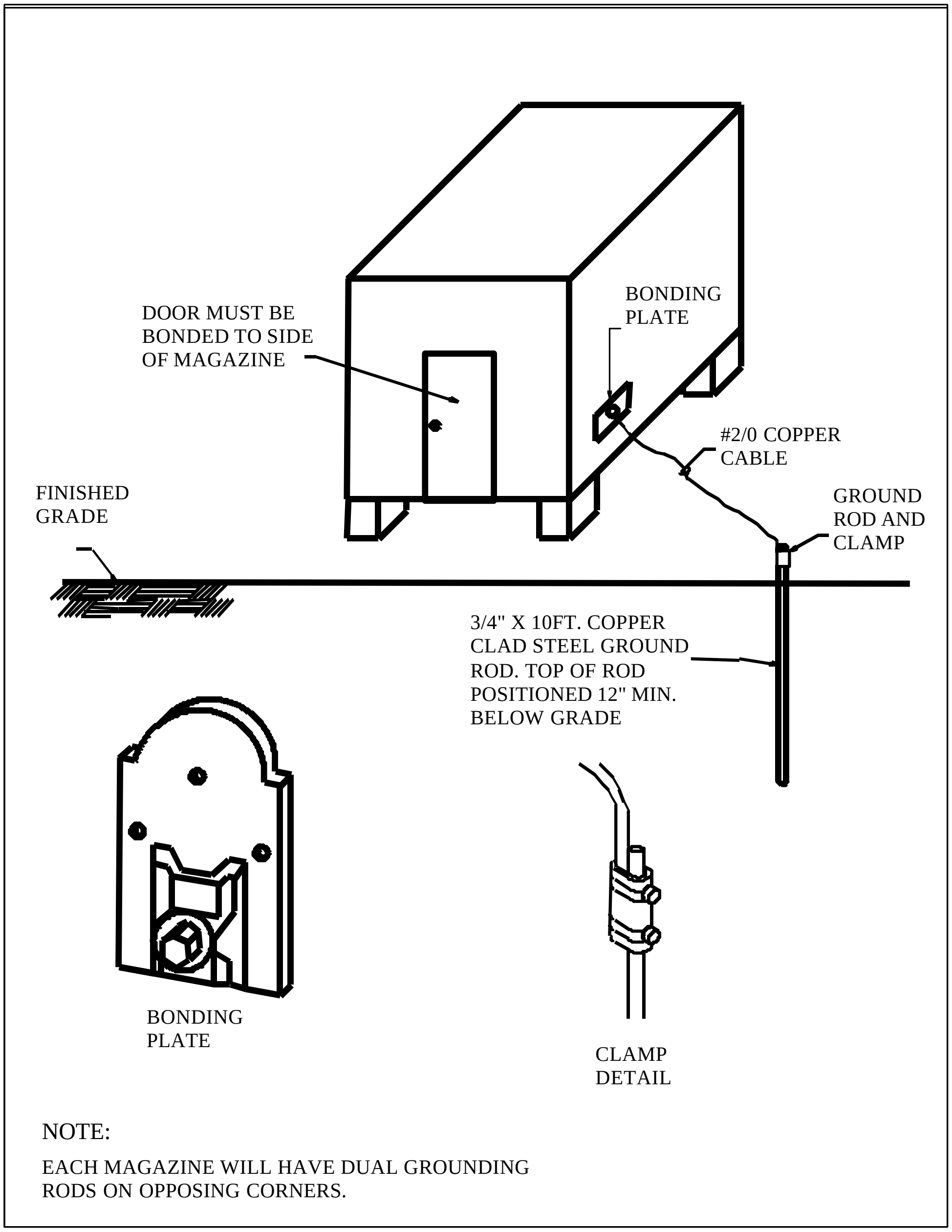

Figure 11-1. Magazine Grounding Detail

(3) In-Grid Consolidated Shots. Minimum separation distances for all personnel should be determined using the requirements for intentional detonations, as discussed in paragraph 11-8. The procedures for in-grid consolidated shots are presented in the USAESCH document "Procedures for Demolition of Multiple Rounds (Consolidated Shots) on Ordnance and Explosives Sites, dated July 1998. This document and the corresponding DDESB approval letter must be available on-site. USAESCH documents are available on the OE MCX website at http://www.hnd.usace.army.mil/oew.

11-10. Engineering Controls. Engineering controls are used to mitigate the effects of unintentional or intentional explosions if the calculated minimum separation distance for the OE items to be destroyed cannot be met. The primary goals of using engineering controls are to improve personnel safety and/or to reduce the minimum separation distance. This paragraph discusses engineering controls that can be used by the project team for either an unintentional or intentional explosion scenario.

a. Engineering Controls for Unintentional Detonations. Engineering controls used for unintentional detonations include the barricade. The project team should design barricades in accordance with approved DOD standards. To implement a barricade that has previous approval by DDESB, the project team should contact the USAESCH Engineering Directorate, Structural Branch. If a barricade has not been previously approved, a complete structural design package should be submitted to the USAESCH Engineering Directorate, Structural Branch as part of the ESS. The structural design package should include design drawings, design details, calculations, drawings, and relevant testing details. The design must show how fragmentation is captured and overpressure is reduced. The design package, as part of the ESS, is forwarded through the appropriate channels to DDESB for approval.

b. Engineering Controls for Intentional Detonations. The most common engineering controls used during intentional detonations are either soil cover or sand bags. If controls are required for intentional explosions, the Design Center should be contacted to arrange for the preparation of a design (or a review of a design already prepared) with the USAESCH Engineering Directorate, Structural Branch.

(1) Soil Cover. If soil is proposed to be used over a to-be-detonated OE, the project team may use one of several computerized models to determine the required thickness of soil cover necessary for the intentional detonation of OE items. The Buried Explosion Module is one such computerized model. The methodology used in this software is documented in HNC-ED-CS-S-97-7-Revision 1. The use of soil as an engineering control reduces the fragment and soil ejecta distances.

(2) Sandbags. Sandbags may be used for an OE item no larger than 155-mm. If sandbags are proposed to be used as an engineering control to mitigate the fragmentation and overpressures generated during an intentional OE detonation, the project team should refer to HNC-ED-CS-S-

98-7, Use of Sandbags for Mitigation of Fragmentation and Explosion Effects Due to Intentional Detonation of Munitions.

(3) On-Site Ordnance Demolition Container (ODC). Another engineering control that may be proposed for the intentional detonation of OE items is the ODC. The ODC has been approved by DDESB for the intentional detonation of OE items. The ODC is designed to contain all significant explosion pressures for a total NEW of up to 6 pounds of TNT or its equivalent. The ODC is designed to capture all fragmentation from OE items with fragmentation characteristics up to those from an 81-mm mortar. When using the ODC, the required minimum separation distance is 75 feet. Detailed design drawings for the ODC and the supporting technical report, HNC-ED-CS-S-97-3, Safety Submission for On-Site Demolition Container for Unexploded Ordnance are available.

ATTACHMENT 11-1
BLAST AND FRAGMENT PROTECTION REVIEW CHECKLIST

Project Name: ____________________
Project Location: ____________________
Design Center POC: ____________________
Reviewer's Name and Title: ____________________
Date of Review: ____________________

	Y	N	N/A
<u>Engineering Considerations for SOW Preparation</u>			
1. Has the SOW properly taken into account the physical characteristics of the site?	____	____	____
2. Has the SOW taken into account the type of OE response action being contemplated?	____	____	____
3. Has the SOW taken into account the characteristics of the probable OE items that will be encountered at the site?	____	____	____
4. Has the correct Most Probable Munition been identified for the site?	____	____	____
<u>Minimum Separation Distances</u>			
1. Are the minimum separation distances being proposed for the site?	____	____	____
2. Have the following criteria for an unintentional detonation been evaluated:			
• Minimum Separation Distance for Unintentional Detonations: Which will provide the greatest distance?			
– Overpressure at a K value of 50?	____	____	____
– Maximum fragmentation distance?	____	____	____
– 200 feet?	____	____	____
• Team Separation Distance: Which will provide the greatest distance:			

	Y	N	N/A
– Overpressure at a K value of 50?	______	______	______
– 200 feet?	______	______	______
3. Have the following criteria for an intentional detonation been evaluated:			
• Minimum Separation Distance for Intentional Detonations: Which will provide the greatest distance?			
– Overpressure at a K value of 328?	______	______	______
– Maximum fragmentation distance?	______	______	______
– 200 feet?	______	______	______

<u>Explosives Siting Plan Review Considerations</u>

	Y	N	N/A
1. Has a map been included with the Explosives Siting Plan and is it at an appropriate scale?	______	______	______
2. Does the map identify the OE areas, the location for the explosives storage magazine, and any planned or established demolition areas?	______	______	______
3. Has the OE area been properly identified and has an appropriate minimum separation distance been calculated for the area?	______	______	______
4. Have the Q-D arcs for the OE areas been drawn from the outermost edge of each area?	______	______	______
5. Has the proposed explosives storage magazine been properly sited?	______	______	______
6. Has the proposed demolition area been properly sited?	______	______	______
7. Have footprint areas for any Blow-in-Place areas, Collection Points, or In-Grid Consolidated Shots been discussed in the Explosives Safety Plan?	______	______	______
8. Has an appropriate team separation distance been identified between intrusive investigation teams in the Explosives Safety Plan?	______	______	______
9. Have any engineering controls been proposed in the Explosives Safety Plan?	______	______	______

Engineering Controls for Unintentional Detonations

1. Barricades. The project team should consider the following elements regarding barricade selection:
    - Have barricades been specified for the project? ______ ______ ______
    - Has the correct barricade been specified for the application in accordance with the DOD standards? ______ ______ ______
    - If the proposed barricade has not been previously approved, has a complete structural design package been submitted to the USAESCH Engineering Directorate, Structural Branch? ______ ______ ______
    - Has the design package been forwarded through appropriate channels to DDESB for review? ______ ______ ______

Engineering Controls for Intentional Detonations

1. Is soil being proposed as an engineering control for an intentional detonation? ______ ______ ______
2. Has the amount of soil to be placed on top of the OE items been properly calculated? ______ ______ ______
3. Are sandbags being proposed as an engineering control to limit the fragmentation and overpressure from an intentional OE detonation? ______ ______ ______
4. Has the amount of sandbags being proposed been properly calculated based on the type of OE to be destroyed? ______ ______ ______
5. Has the Ordnance Demolition Container (ODC) been specified to be used on the site? ______ ______ ______
6. Is the ODC capable of safely containing the blast and fragmentation effects of the munitions to be found at the site? ______ ______ ______